AD-A106 436 BLACK AND VEATCH KANSAS CITY MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. RAY COUNTY DAM NUMBER A-27 (MO 102--ETC(U)
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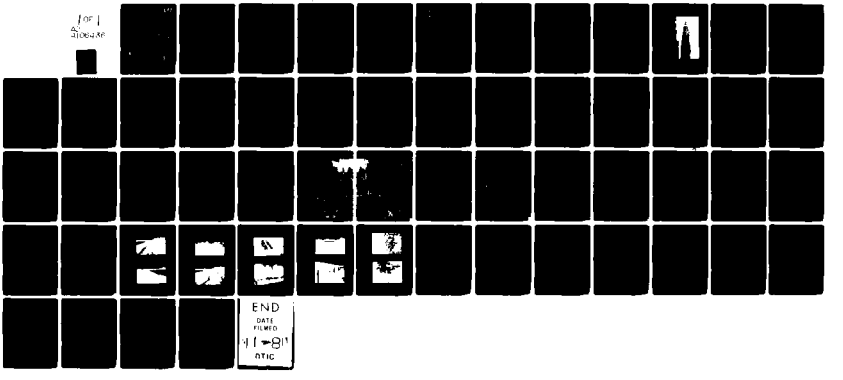

LEVEL II

1

MISSOURI-KANSAS CITY BASIN

RAY COUNTY DAM NO. A-27

RAY COUNTY, MISSOURI

MO 10233

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1979

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9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

National Dam Safety Program. Ray County Dam Number A-27 (MO 10233), Missouri - Kansas City Basin, Ray County, Missouri. Phase I Inspection Report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

RAY COUNTY DAM NO. A-27

RAY COUNTY, MISSOURI

MO 10233

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
... Serving the Army
... Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Ray County Dam No. A-27. Mo. I.D. No. 10233
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Ray County Dam No. A-27:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED
Chief, Engineering Division

20 SEP 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

20 SEP 1979
Date

RAY COUNTY DAM NO. A-27

RAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10233

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

MAY 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Ray County Dam No. A-27
State Located	Missouri
County Located	Ray County
Stream	Tributary to Willow Creek
Date of Inspection	17 May 1979

Ray County Dam No. A-27 was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten the life and property of approximately three families downstream of the dam and would potentially cause appreciable damage to State Highway 210, and Ray County Dam No. A-1 within the estimated damage zone which extends approximately three miles downstream of the dam.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass either the probable maximum flood or 50 percent of the probable maximum flood without overtopping but will pass 30 percent of the probable maximum flood and the 100-year flood. Considering the small volume of water impounded and the downstream hazard, 50 percent of the probable maximum flood is the appropriate spillway design flood.

Deficiencies visually observed by the inspection team were lack of riprap slope protection, erosion, seepage, and animal burrows in the embankment.

There were no observed deficiencies or conditions existing at the time of the inspection which indicate an immediate safety hazard. future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

Paul R. Zaman, PE
Illinois 62-29261

Edwin R. Burton, PE
Missouri E-10137

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
RAY COUNTY DAM NO. A-27

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Ray County Dam No. A-27 be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The Ray County Dam No. A-27, hereafter referred to in this report as Dam No. A-27, is a recently constructed earthen structure located in south-central Ray County, Missouri on an unnamed tributary to Willow Creek. This structure was designed by the Soil Conservation Service and was constructed under their supervision. The principal purpose of this dam is grade stabilization. Dam No. A-27 is an integral part of the Willow Creek Watershed plan and is located on property owned by Mr. Robert Vandiver of Camden, Missouri. The dam is 14 feet wide at the crest, 635 feet long, and 34 feet high at the principal spillway. The structure has an emergency spillway located at the left abutment and a principal spillway located near left-center of the dam.

(2) A grass-lined emergency spillway is located at the left abutment. It consists of grass-lined approach and discharge channels. These channels have trapezoidal cross-sections. The spillway is separated from the dam by protective berms.

(3) A principal spillway consisting of a 30-inch diameter CMP drop inlet with trash rack and anti-vortex plate and 21-inch diameter CMP slotted flume discharge pipe has been provided at this dam. The slotted flume discharge pipe is bedded in riprap and ultimately discharges to the natural channel bottom.

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in south-central Ray County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Camden, Missouri in Section 11 of T51N, R28W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Ray County Dam No. A-27 has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Dam No. A-27 the estimated flood damage zone extends downstream for approximately three miles. Within the damage estimated zone are three homes, farm buildings, State Highway 210, one improved road crossing, and Ray County Dam No. A-1. The Richmond, Missouri water treatment plant is also located within the damage zone.

e. Ownership. The dam is owned by the Willow Creek Watershed Subdistrict, P.O. Box 380, Richmond, Missouri 64085 and is located on the property of Mr. Robert Vandiver, Camden, Missouri 64107.

f. Purpose of Dam. The dam forms a grade stabilization pool with a 168 acre-feet total sediment storage capacity at the principal spillway elevation.

g. Design and Construction History. Data relating to the design and construction were made available by the Soil Conservation Service (SCS), Columbia, Missouri.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation and the capacity of the uncontrolled spillway all combine to maintain a relatively stable water surface elevation.

i. Maintenance. The Willow Creek Watershed Subdistrict, Box 380, Richmond, Missouri 64085 is responsible for maintenance at this dam.

1.3 PERTINENT DATA

a. Drainage Area - 231 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled principal spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated combined spillway capacity - 235 cfs (Reservoir surface @ minimum top of Dam El. 760.9).

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 760.9 ± (see Plate 3)

(2) Principal spillway crest - 755.9

(3) Emergency spillway crest - 758.8 (Average)

(4) Streambed at centerline of dam - 727.0 ±

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 2,900 feet ± (at top of dam)

(2) Length of normal pool - 2,200 feet ± (at principal spillway curve)

e. Storage (Acre-feet).

(1) Top of dam - 293 (computed by HEC-1)

(2) Principal spillway crest - 168 (from SCS elevation-storage area)

(3) Emergency spillway crest - 232 (computed by HEC-1)

(4) Design surcharge - 79 (Uncontrolled storage at SCS design maximum pool elevation 759.62 for a peak design inflow of 951 cfs).

f. Reservoir Surface (Acres).

(1) Top of dam - 30.0

(2) Principal spillway crest - 17.4 (SCS survey data)

(3) Emergency spillway crest - 24.7

(4) Design surcharge - 26.8

g. Dam.

(1) Type - Earth embankment

(2) Length - 635 ± feet

(3) Height - 34 feet ±

(4) Top width - 14 feet

(5) Side slopes - varies (see Plate 4)

(6) Zoning - None.

(7) Impervious core - None.

(8) Cutoff - Core trench, earth fill.

(9) Grout curtain - None.

h. Diversion and Regulating Tunnel - None.

i. Emergency Spillway.

(1) Type - Grass open channel.

(2) Width of spillway - 20 feet bottom width, side slopes 3.0 H on 1.0 V

(3) Crest elevation - 758.8 feet m.s.l. (average)

(4) Gates - None.

(5) Upstream channel - Grass lined.

(6) Downstream channel - Grass lined.

j. Principal Spillway.

(1) Type - Drop inlet with vertical shaft.

(2) Size of entrance - 30 inch.

(3) Crest elevation - 755.9 feet m.s.l.

(4) Upstream channel - Not applicable.

(5) Downstream channel - Natural stream.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were available in the form of construction logs, "As-Built" drawings, SCS project engineer's recommendations, SCS design memorandum, and the Willow Creek Watershed - Work Plan (3). Seepage analyses were not available.

2.2 CONSTRUCTION

Construction logs were available. The Contractor, Ira R. Thornton, Richmond, Missouri was noted in the logs as 'doing good work' and that some of the work was done without inspectors present. The dam was completed in August 1972.

2.3 OPERATION

Documentation of past floods was not available.

2.4 GEOLOGY

Dam No. A-27 is located across a broad shallow valley formed in modified loess. The geology of the site consists of the Wabash or Marshall Silt Loam soil series overlying glacial till or shale bedrock of the Marmaton Group of Pennsylvanian System. The Wabash soil series is an alluvial soil developed along the drainage course and derived from material eroded from the surrounding slopes. For engineering purposes, it can be classified as a silt (ML) or silty clay (CL). The Marshall Silt Loam Soil series consists of modified loess and is classified for engineering purposes as a silt (ML) or silty clay (CL).

The foundation and abutments of the dam consist of silty clay (CL) soil derived from loess and Kansas glacial till overlying shale bedrock as shown on the design drawings for the dam. The Kansan Till contains pockets of silty and clayey sand (SC-SM). The bedrock contact is approximately 20 feet in depth below the original grade.

The downstream channel is formed in modified loess and glacial till. No outcrops of bedrock were observed in the channel.

2.5 EVALUATION

a. Availability. Engineering data were obtained as noted in Section 2.1.

b. Adequacy. Engineering data were available from which to make an assessment of the design, construction, and operation. Seismic

stability analyses were performed by Black & Veatch using available data as noted in section 6.

c. Validity. The available engineering data on the design, construction, and operation were determined to be valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Dam No. A-27 was made on 17 May 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. In general, the embankment appeared to be in good condition. Minor deficiencies observed for this structure consist primarily of erosion. There is no riprap slope protection for this embankment. Slope protection is provided by grass. As a result, the upstream slope in contact with the reservoir has suffered some minor wave induced erosion. There is some erosion activity in proximity to both right and left abutment-embankment contacts and to the emergency spillway channel bottom. A few animal burrows were located on the upstream embankment slope. There was evidence of seepage on the left abutment-embankment contact. The seepage was observed to be clear and less than 1 gpm. There was also evidence of erosion and either seepage or poor drainage in the vicinity of the slotted flume discharge conduit near the toe of the embankment. There was no evidence of sliding, cracking, settlement or sinkholes observed. Minor siltation was noted in the reservoir pool area.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The principal spillway consists of a 30-inch corrugated metal pipe vertical shaft connected to a 21-inch corrugated metal pipe conduit through the dam connecting to a 21-inch slotted flume. The reservoir level was approximately 0.2 foot below inlet. The vertical shaft and slotted flume appeared to be in good condition with no rust or corrosion evident. The emergency spillway consists of an earth cut through the natural overburden of the left abutment. The channel was grass covered CL soil.

d. Geology. A visual inspection of the soils and geology of the dam confirmed the presence of silt-loam soil overlying residual silty clay soil. Some alluvial sand and gravel are present in the downstream channel below the dam. The materials in the foundation and abutments of the dam consist of silty clay (CL) overlying shale as indicated on the design drawings.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. Minor siltation has occurred in the reservoir pool.

f. Downstream Channel. The natural channel downstream from the principal spillway consists of a gravel streambed. No outcropping of shale and limestone were visible downstream of the dam. The stream banks are covered with brush and trees.

3.2 EVALUATION

The various deficiencies observed at this dam are, for the most part, minor and can be remedied by normal maintenance practices. The potential for failure resulting from these deficiencies is not great and with the exception of the seepage at the left abutment contact it is unlikely that they will become a problem in the foreseeable future. The seepage through the left abutment-embankment may become a problem with time. Periodic observations and/or monitoring of the left abutment seepage is warranted and an engineer experienced in seepage control should be consulted.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is normally controlled by rainfall, runoff, transpiration, evaporation, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

Under terms of the Soil Conservation Services' watershed program for Willow Creek, Ray County, Missouri maintenance for Dam No. A-27 is the responsibility of the Willow Creek Watershed Subdistrict, Richmond, Missouri.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities are known to exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN AFFECT

There is no existing system or preplanned scheme for warning occupants of the hazard zone below this dam.

4.5 EVALUATION

The existing maintenance program appears to be adequate for a structure of this type and age. Minor corrective measures as suggested elsewhere in this report should be implemented to keep this dam in its visibly good condition. Particular attention should be directed at the seepage problem at the left abutment-embankment contact. This deficiency could possibly lead to deterioration of the dam embankment.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data pertaining to hydrology and hydraulics were available. Independent calculations were, however, performed for this report in accordance with the referenced guidelines.

b. Experience Data. The drainage area and reservoir surface area are developed from USGS Camden Quadrangle Map. The spillway and dam layouts are from surveys made during the inspection and available design documents.

c. Visual Observations.

(1) The 30-inch corrugated metal pipe drop inlet of the principal spillway appears to be in good condition. There was riprap along the outlet of the 21-inch discharge pipe slotted flume of the principal spillway, the discharge channel appeared in good condition with little erosion.

(2) The emergency spillway channel is in good condition with minor evidence of erosion at the time of the inspection.

(3) Spillway releases will not endanger the integrity of the dam.

(4) There are no facilities available that could serve to draw down the pool.

(5) The principal spillway is located near the left-center of the dam. The emergency spillway is located in the left abutment.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 30 percent of the probable maximum flood and the 100-year flood without overtopping. The estimated ungated combined spillway capacity at maximum pool elevation during the probable maximum flood is 540 cfs. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded and the downstream hazard, 50 percent of the probable maximum flood is the appropriate spillway design flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,200 cfs of the total discharge from the reservoir of 2,740 cfs. The estimated duration of overtopping is 5.7 hours at a

depth of 1.7 feet. The portion of the estimated peak discharge of 1/2 of the probable maximum flood overtopping the dam would be 410 cfs of the total discharge of the reservoir of 735 cfs. The estimated duration of overtopping is 3.4 hours at a depth of 0.8 feet.

There is evidence that the silty soils typical of the embankment surfaces tend to erode. Although the inspection team found no evidence of overtopping of the embankment, prolonged overtopping of the embankment is believed to cause erosion which could lead to failure.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately three miles downstream of the dam. There are three homes and two improved road crossings downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur. Ray County Dam No. A-1 is located about 0.7 miles downstream of Dam No. A-27 and the Richmond, Missouri water treatment plant is located approximately 2.7 miles downstream.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. Design data relating to the structural stability of the dam were available from the United States Department of Agriculture, Soil Conservation Service, Soil Mechanics Laboratory, Subject: ENG 22-5, Missouri WP-98, Willow Creek, Site No. A-27 (Ray County), dated October 11, 1972. "As-Built" construction drawings were available from the Soil Conservation Service.

As reported in the SCS data, samples for testing were obtained from borings located within the borrow area and the dam foundation area. Eight jar samples, two large bag samples and three core samples were submitted to the laboratory to represent foundation materials. Five large bag samples were submitted to the laboratory to represent materials in the borrow area.

Laboratory tests performed by the SCS for the dam design included:

(1) Foundation Area:

- (a) Consolidation Test
- (b) Permeability Test
- (c) Consolidated Undrained Triaxial Shear Test
- (d) Atterburg Limit Test
- (e) Standard Proctor Test
- (f) Sieve Analysis
- (g) Moisture Content

(2) Embankment Area:

- (a) Standard Proctor Test
- (b) Atterburg Limit Test
- (c) Consolidated Undrained Triaxial Shear Test
- (d) Sieve Analysis

c. Stability Loading Conditions:

Stability analyses by the SCS for the dam design included the consideration of two loading conditions.

(1) Full Drawdown

(2) Steady Seepage

d. Stability Analysis

(1) Full Drawdown: The full drawdown loading condition was analyzed for the upstream embankment slope. The slope stability analysis was made on a 2 1/2 H:1 V embankment slope using the Modified Swedish Circle Method. Rapid drawdown from the emergency spillway to the base of the embankment was considered in the available analysis. Soil properties used for this analysis were determined from consolidated undrained triaxial shear tests and were representative of embankment and foundation materials. The embankment slope for the stability analyses considered a 10-foot berm located at elevation 756.0. The construction drawings indicate that this berm was increased to 20 feet.

The minimum factor of safety reported for the full drawdown loading condition was 1.19.

(2) Steady Seepage: The steady seepage loading condition was analyzed for the downstream slope. The stability analysis was made on a 2 1/2 H:1 V embankment slope with a full phreatic line (no drain) considered. The soil properties for the embankment and foundation materials were obtained from consolidated undrained triaxial shear tests. Stability determinations were conducted using the prescribed soil properties. The construction drawings indicate a larger 18-foot berm was constructed above the two 10-feet wide berms which were used in the stability analysis. The embankment slope below this berm was constructed as a 3 H:1 V slope which would slightly increase the stability of the constructed embankment over the embankment used in the steady seepage analysis.

A minimum factor of safety of 1.30 was reported for the steady seepage loading condition.

e. Evaluation. The available stability analyses included soil properties, parameters, and resulting factors of safety for full drawdown and steady seepage loading conditions.

The stability analysis results for the full drawdown loading condition indicated a factor of safety of 1.19 for the upstream slope which is acceptable in accordance with the suggested value as per Appendix D of the guidelines. The 20-feet wide upstream berm as constructed also provides increased stability over the 10-feet wide berm used in the stability analysis. The full drawdown condition used in the stability analysis is a more critical assumption than the actual potential drawdown condition for the embankment because there are no physical provisions for rapidly lowering the water level the full reservoir depth.

The factor of safety reported for the steady seepage loading condition was 1.30 which is less than the suggested value of 1.5 as per Appendix D of the guidelines. Based upon our review of the soil strength properties and assumptions used in the stability analysis as described by the SCS report, in our opinion the embankment is adequately designed for the steady seepage condition. The factor of safety for the steady seepage condition was obtained using total strength soil parameters in an effective stress analysis thereby providing conservative results.

Stability analyses for the partial pool loading condition were not available. The conditions, assumptions and strength parameters for full drawdown and steady seepage stability analysis represent a more critical stability condition than for partial pool.

Stability analyses for the earthquake loading condition were not available. The dam is located within Seismic Zone 1 with a designated seismic coefficient of 0.025 to be used in the conventional equivalent static force method of analysis. An assessment of seismic stability is provided in paragraph h below.

Seepage analyses for this dam were not available. A cutoff trench was constructed to reduce the potential for seepage. The embankment was constructed of low permeability CL materials. Seepage observed on the downstream left abutment does not appear critical but should be monitored.

f. Operating Records. No operational records were available for review by the inspection team.

g. Post Construction Changes. No known post construction changes exist.

h. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. Stability analyses were performed by Black & Veatch using a seismic coefficient of 0.05 (Seismic Design Coefficient as per Department of the Army, Corps of Engineers, EM 1110-2-1902) applied to the critical failure arc for each of the full drawdown and steady seepage analyses. The calculated factors of safety were

greater than 1, the suggested value of Appendix D of the guidelines. The seismic stability requirements of the guidelines are satisfied.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Ray County Dam No. A-27 was observed to have minor deficiencies by the inspection team. Seepage in the area of the contact between embankment and abutment materials on the left end is a primary concern. Of lesser concern relative to the dams immediate safety evaluation is the absence of riprap slope protection. In the event the pool attains a high water level coupled with wind action, the upstream face of the dam will be subjected to erosion forces, which if not controlled could develop into a potential hazard. Other deficiencies observed are siltation, animal burrows and various locations with erosion gullies.

b. Adequacy of Information. The conclusions in this report were based on performance history, visual conditions, and the available engineering design. The inspection team considers that these data are sufficient to support the conclusions herein.

c. Urgency. It is the opinion of the inspection team that steps be taken through maintenance activities to remedy the documented deficiencies. If the deficiencies listed elsewhere in this report are not remedied in the near future, they will continue to deteriorate and lead to a potential of failure.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. The dam is considered to be adequately designed and constructed to withstand an earthquake normally expected for the area.

7.2 REMEDIAL MEASURES

a. Alternatives. The present spillway has the capacity to pass 30 percent of the probable maximum flood without overtopping the dam. In order to pass 50 to 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased or the lake level would need to be lowered to increase storage capacity.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

(1) Erosion of the upstream slope should be monitored regularly and erosion protection should be added on the upstream slope of the dam to prevent erosion of the embankment material due to wave action.

(2) Check the downstream face of the dam periodically for increased seepage and stability problems. If seepage flows are observed to have increased or sloughing on the downstream embankment slope is noted, the dam should immediately be inspected and the condition evaluated by an engineer experienced in design and construction of earthen dams.

(3) A program should be initiated to measure both quantity and quality of seepage through this dam. In the event either or both parameter is shown to increase, an engineer experienced in earth dam design should be consulted.

(4) The existing small animal burrows should be excavated, filled, and compacted under the guidance of a qualified engineer and a program of pest control established to reduce the animal population.

(5) Seepage analyses should be performed by a professional engineer experienced in the design and construction of dams.

(6) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. Frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.

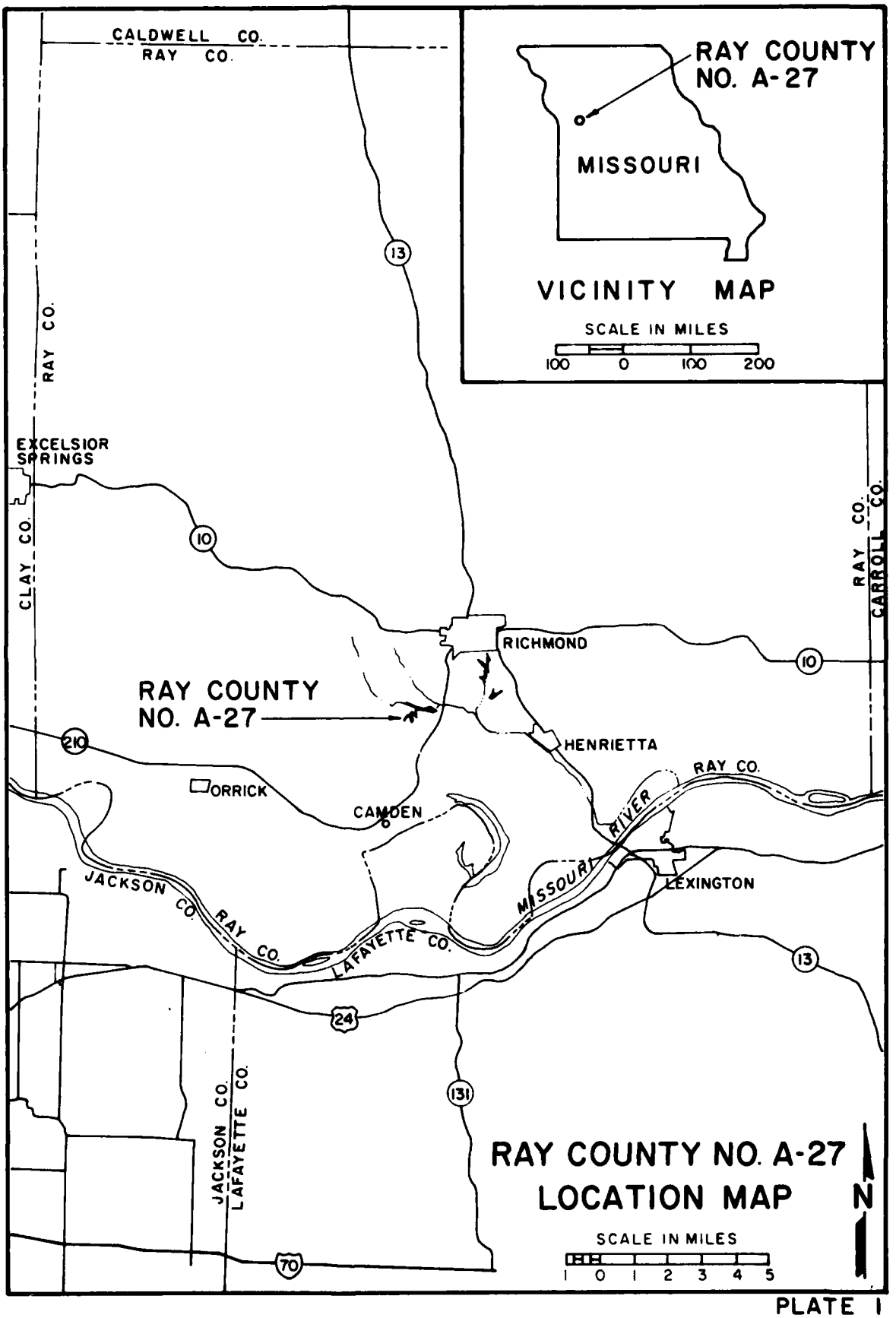
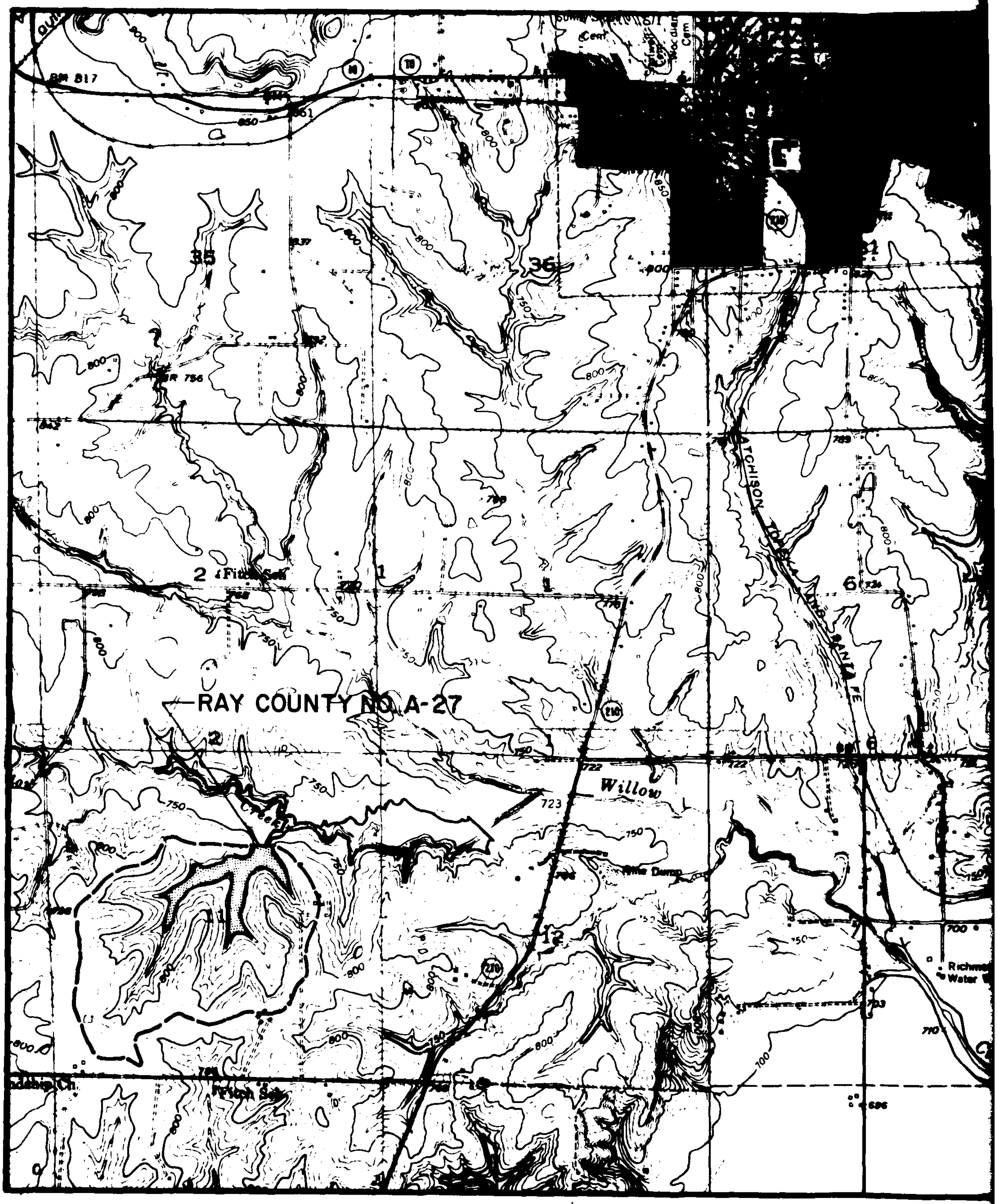
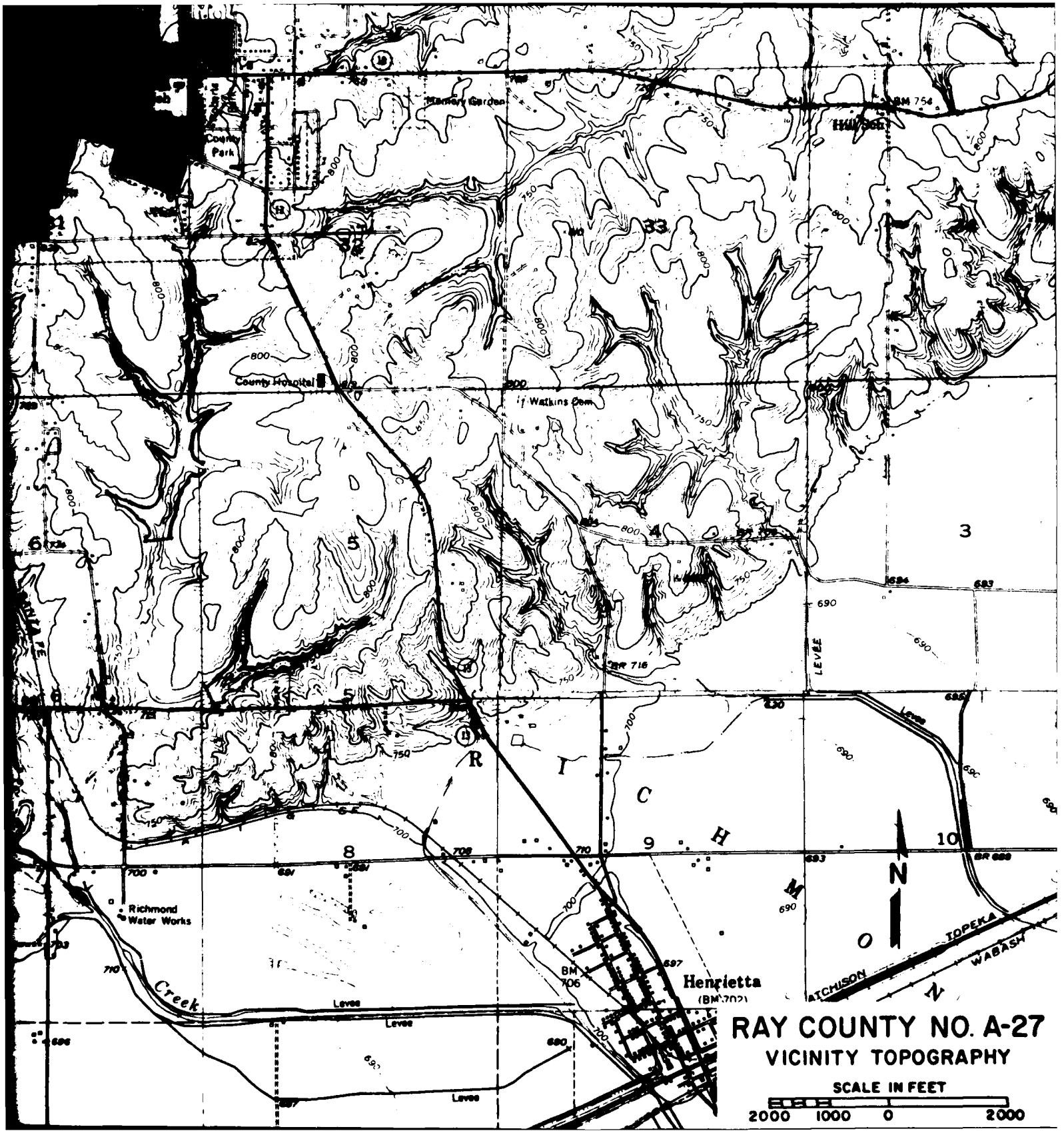

CALDWELL CO.
RAY CO.
RAY COUNTY
NO. A-27
MISSOURI
VICINITY MAP
SCALE IN MILES
100 0 100 200
RAY CO.
EXCELSIOR
SPRINGS
CLAY CO.
13
10
RICHMOND
RAY CO.
CARROLL CO.
RAY COUNTY
NO. A-27
210
HENRIETTA
ORRICK
CAMDEN
RAY CO.
MISSOURI RIVER
LEXINGTON
JACKSON CO.
RAY CO.
LAFAYETTE CO.
24
13
131
JACKSON CO.
LAFAYETTE CO.
70
RAY COUNTY NO. A-27
LOCATION MAP
N
SCALE IN MILES
1 0 1 2 3 4 5

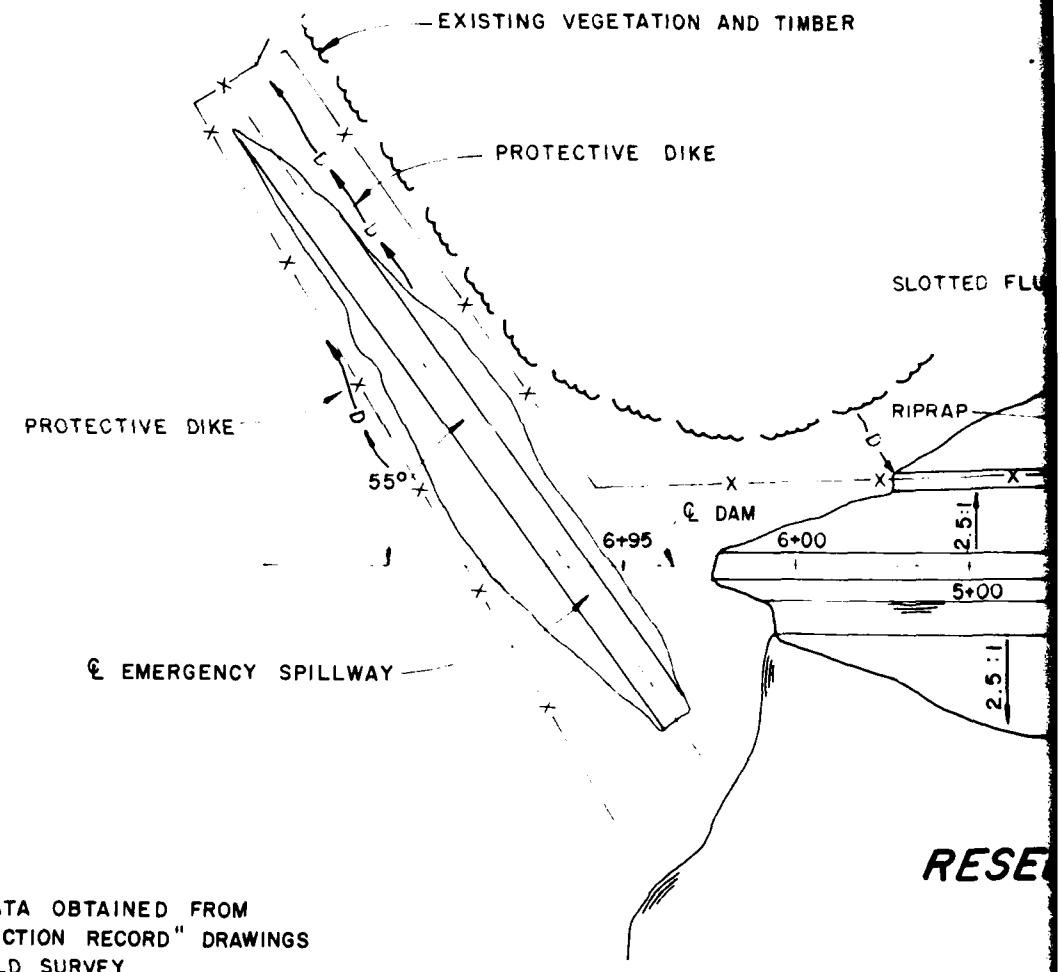
PLATE 1


RAY COUNTY NO. A-27
Willow
Creek
ATCHISON
SANTA FE
35
36
2
1
6
12
BM 817
800
750
850
700



RAY COUNTY NO. A-27

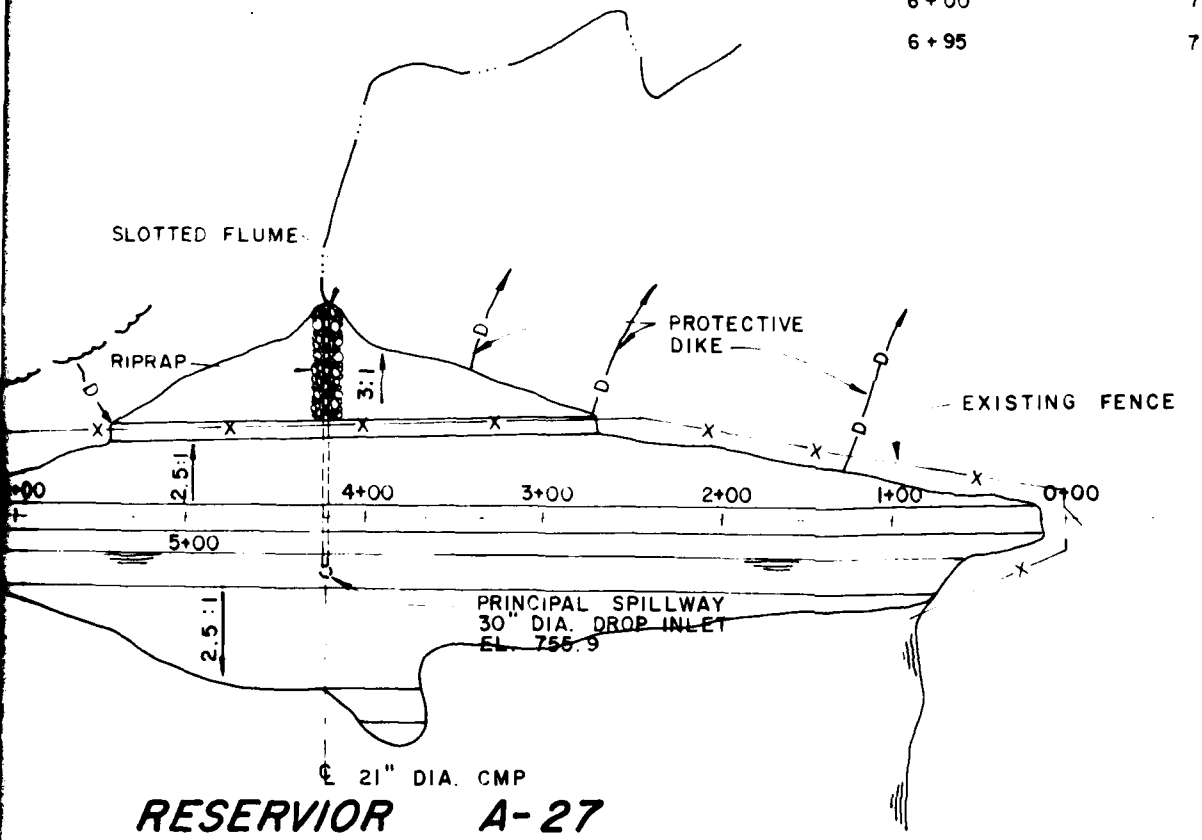
VICINITY TOPOGRAPHY



NOTE: PLAN DATA OBTAINED FROM "CONSTRUCTION RECORD" DRAWINGS AND FIELD SURVEY.

RESE

STATION	℄ ELEVATION
0+00	761.4
1+00	760.9
2+00	761.6
3+00	761.9
4+00	761.9
5+00	761.8
6+00	761.0
6+95	762.4

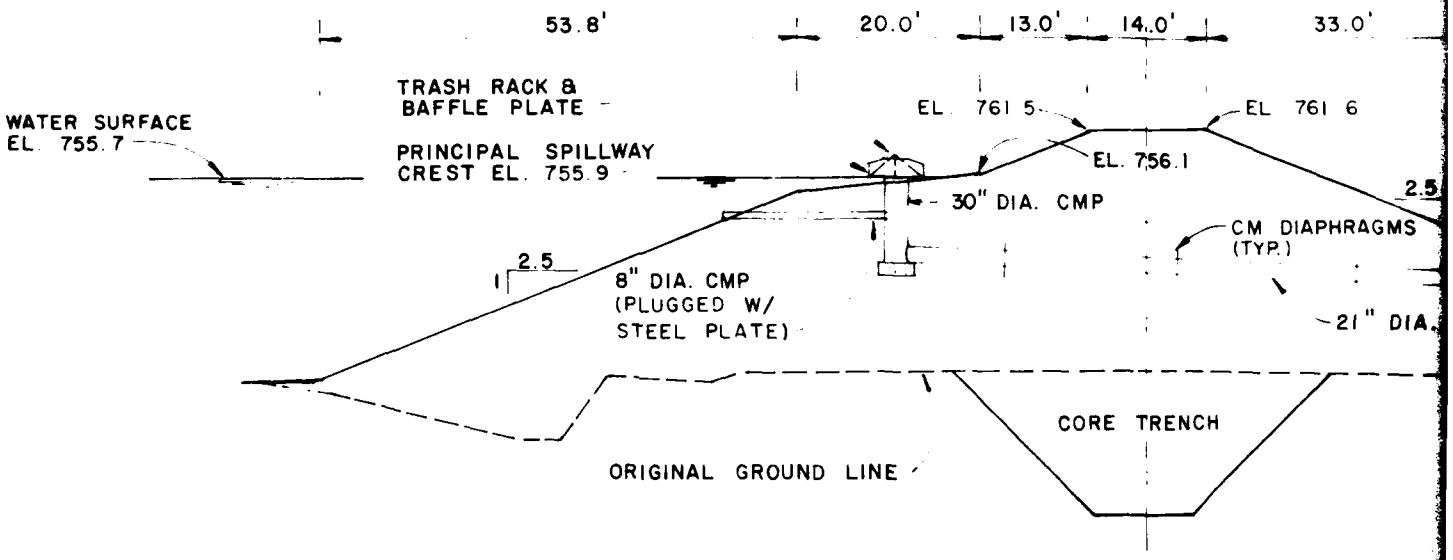


RESERVIOR A-27

N

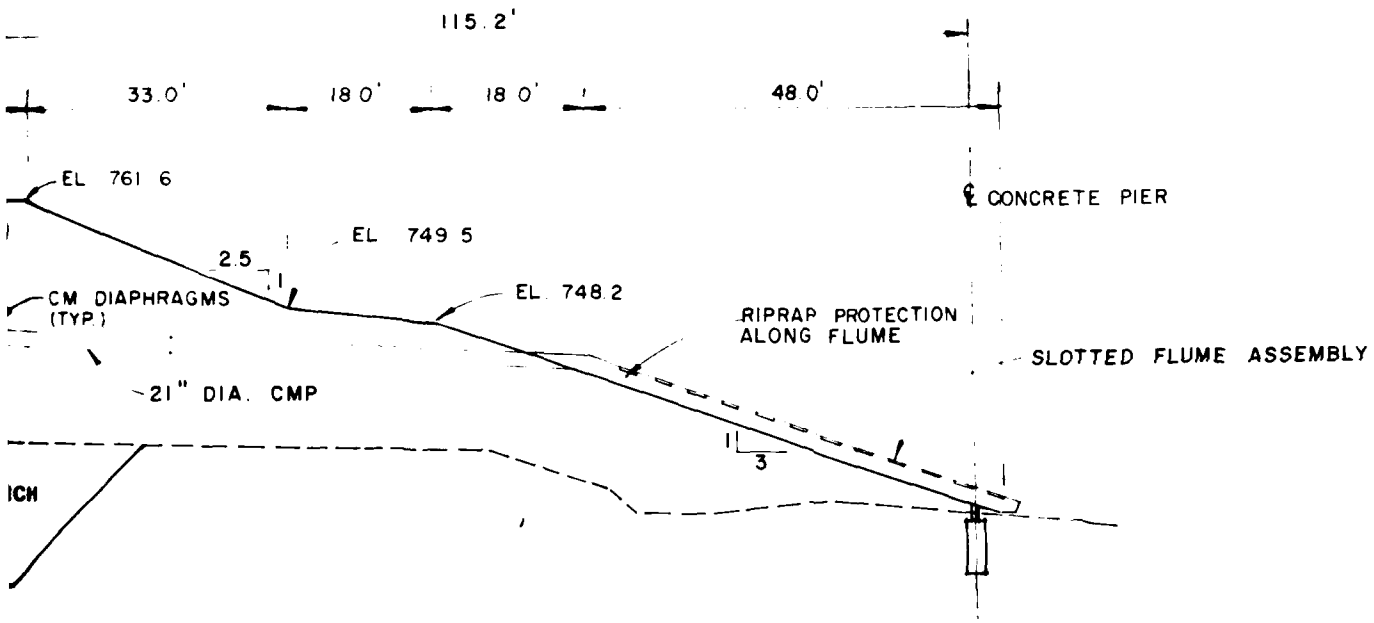
RAY COUNTY NO. A-27
PLAN

PLATE 3



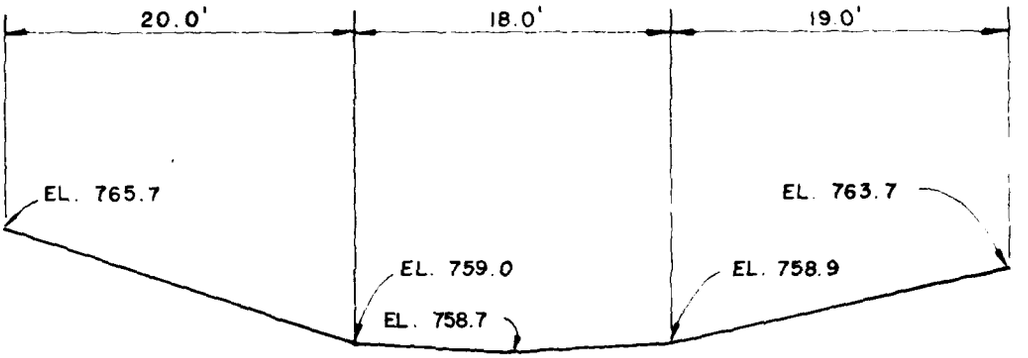
NOTE: CROSS-SECTION AND SPILLWAY DATA OBTAINED FROM "CONSTRUCTION RECORD" DRAWINGS AND FIELD SURVEY.

ELEVATIONS TAKEN APPROXIMATELY 50' WEST OF PRINCIPAL SPILLWAY.



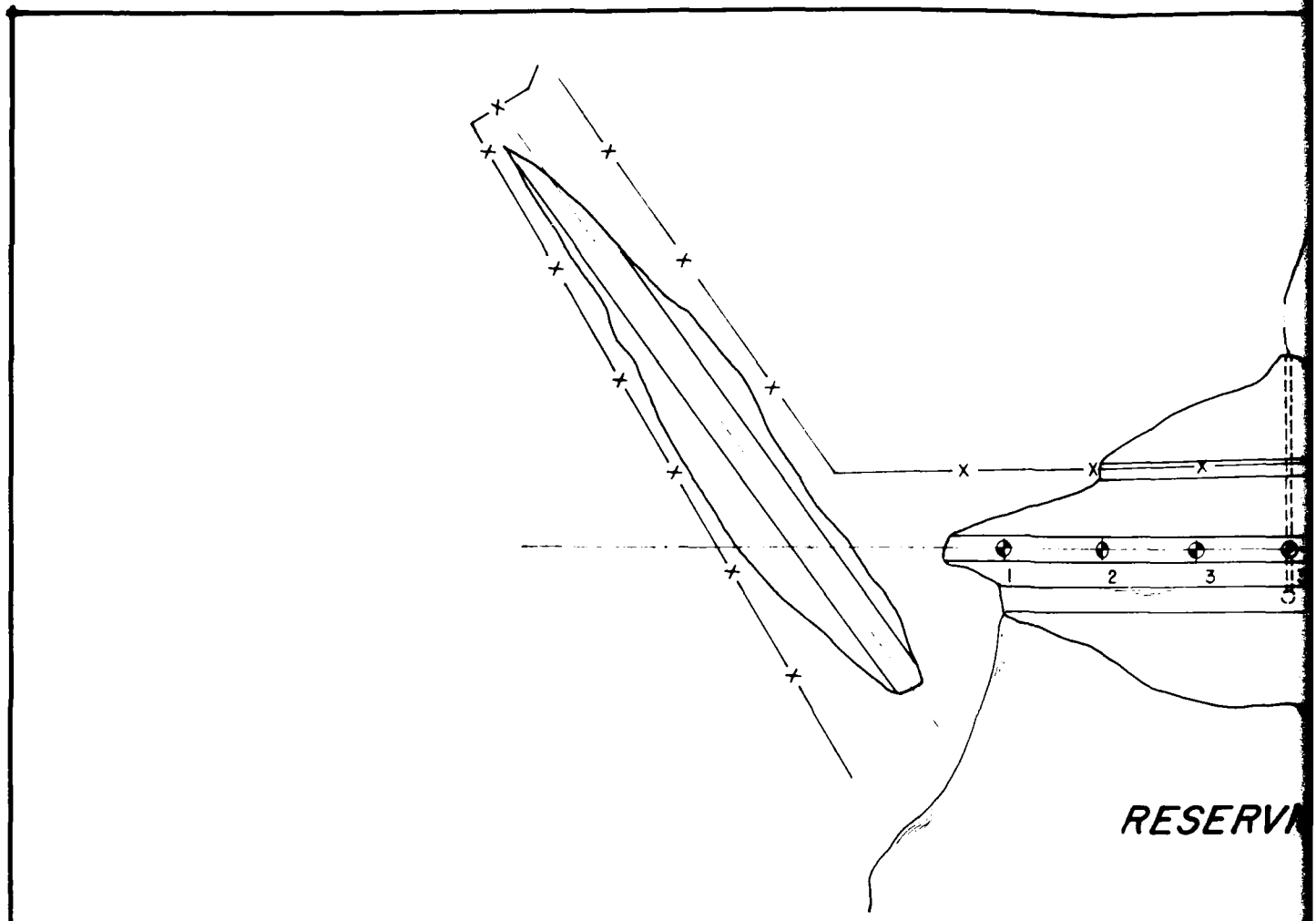
RAY COUNTY NO. A-27
TYPICAL SECTION

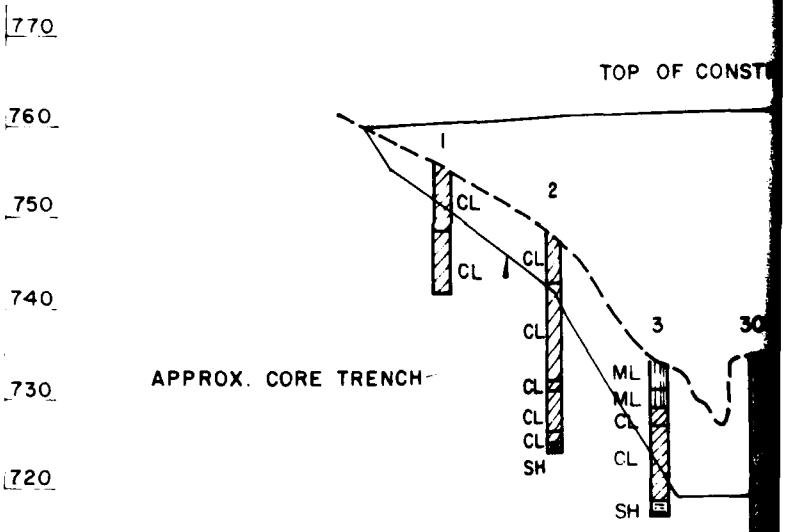
PLATE 4

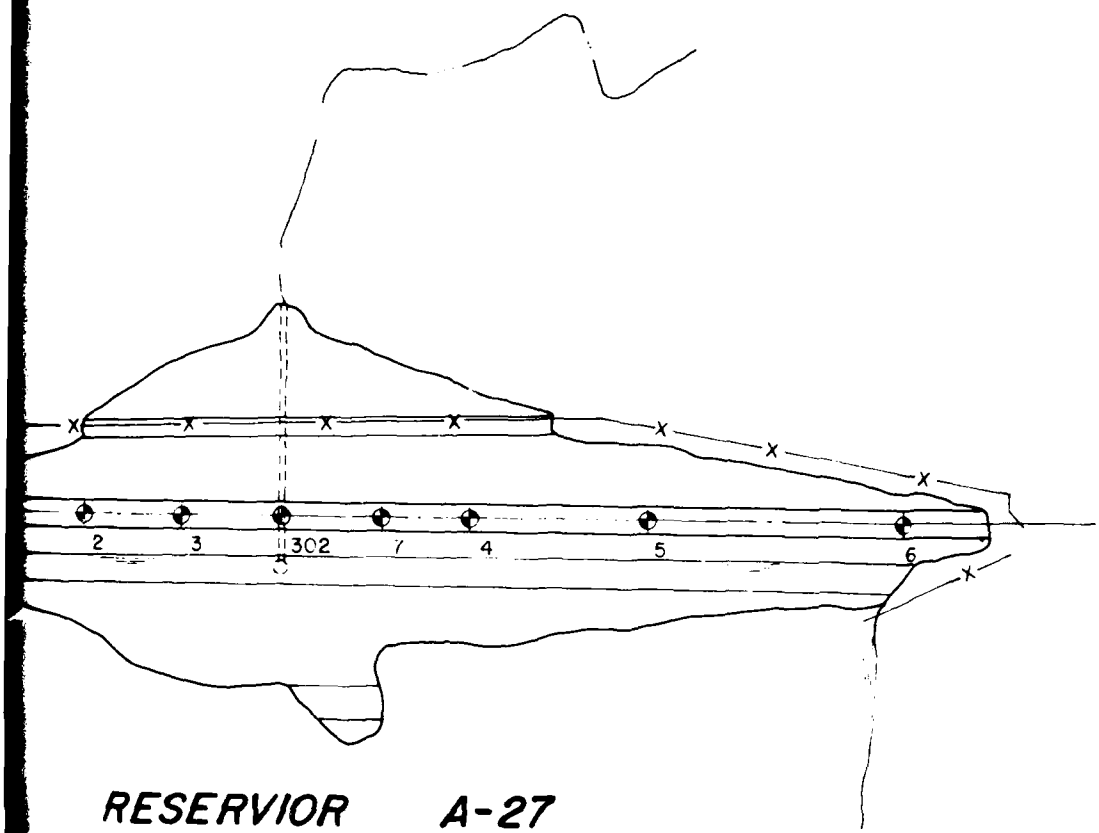


RAY COUNTY NO. A-27
EMERGENCY SPILLWAY SECTION

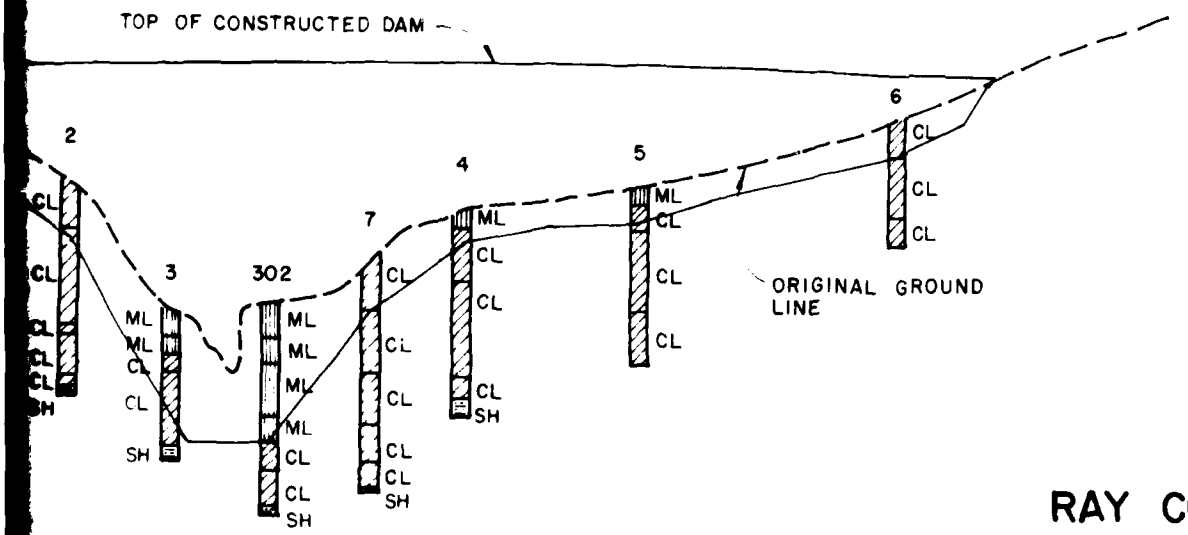
PLATE 5


1
2
3
RESERVI


770
760
750
740
730
720
TOP OF CONST
APPROX. CORE TRENCH
1
2
3
CL
CL
CL
CL
CL
CL
CL
SH
ML
ML
CL
CL
SH

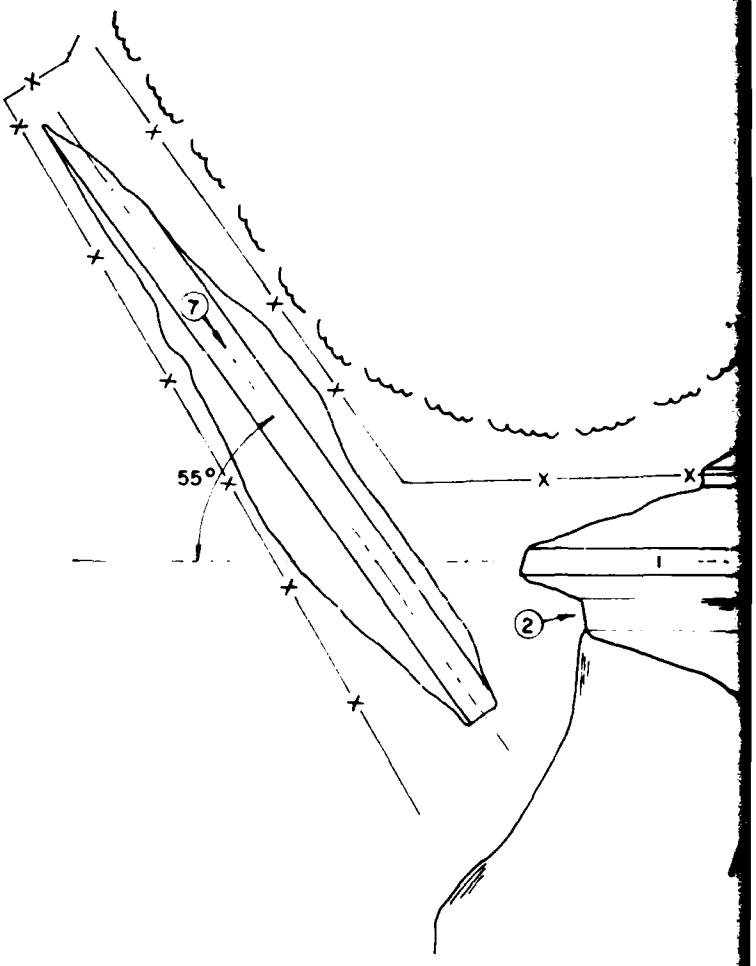


RESERVIOR A-27



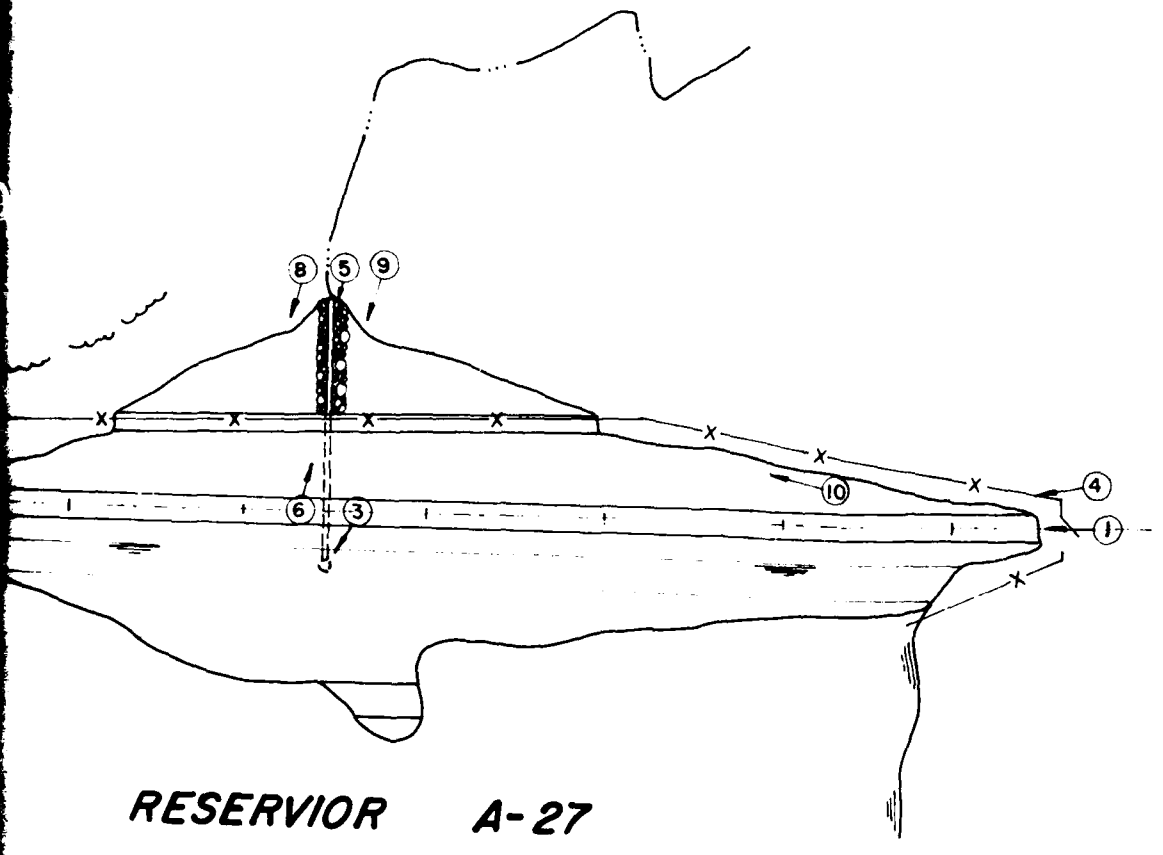
RAY COUNTY NO. A-27
BORING PLAN

PLATE 6



LEGEND

① → PHOTO LOCATION AND DIRECTION



RESERVIOR A-27

N

RAY COUNTY NO. A-27
PHOTO INDEX

PHOTO 1: CREST OF DAM LOOKING WEST

PHOTO 2: UPSTREAM EMBANKMENT WITH PRINCIPAL SPILLWAY INLET

PHOTO 3: PRINCIPAL SPILLWAY INLET WITH TRASH RACK AND ANTI-VORTEX PLATE

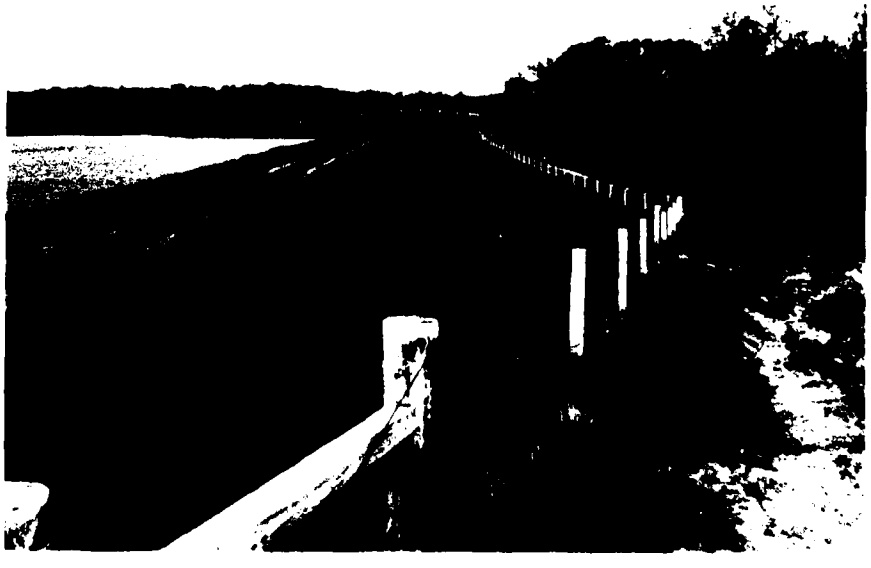


PHOTO 4: DOWNSTREAM EMBANKMENT

PHOTO 5: PRINCIPAL SPILLWAY SLOTTED DISCHARGE FLUME

PHOTO 6: PRINCIPAL SPILLWAY DISCHARGE CHANNEL - TRIBUTARY STREAM TO WILLOW CREEK

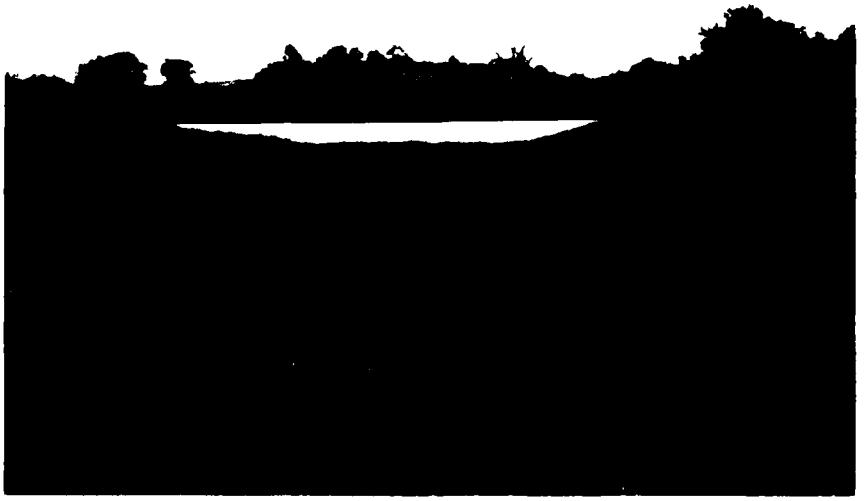


PHOTO 7: EMERGENCY SPILLWAY

PHOTO 8: POSSIBLE SEEPAGE AND/OR INADEQUATE DRAINAGE AT TOE OF EMBANKMENT

PHOTO 9: EROSION AND SEEPAGE AT TOE OF EMBANKMENT, LEFT OF OUTLET FLUME

PHOTO 10: EROSION GULLY AT TOE OF EMBANKMENT

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs. Hydrologic inputs are as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.5
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%

b. Drainage area = 231 acres.

c. Time of concentration:

$$T_c = (1.67)\ L$$

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1{,}900Y^{0.5}}$$

L = lag in hours

ℓ = hydraulic length of watershed in feet

$S = \frac{1{,}000}{CN} - 10$ (where CN is the retardance factor and is equivalent to the runoff curve number)

Y = average watershed land slope in percent

T_c = 0.48 hours (2).

d. The soil association in this watershed is mainly Marshall and Wabash. (3)

e. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 84 and antecedent moisture condition III.

2. Principal spillway release rates are based on a combination of both the weir and pipe flow equations.

Weir equation:

$$Q = CLH^{1.5}$$ (C = 3.33, L = 7.85 feet, H is the head on the weir in feet).

Pipe flow equation:

$$Q = Ca\ (2gh)^{0.5}$$ (C = 0.4, a = 2.41 sq ft, g = 32.2 ft/sec^2, h = difference in reservoir elevation and tailwater elevation).

Emergency spillway release rates were determined from calculations of critical depth of flow at the crest. Reservoir elevations corresponding to given spillway release rates were calculated by adding the critical depth, d_c; the velocity head, $V^2/2g$; and the friction head, h_f.(4).

Discharge rates over the top of the dam are based on the nonlevel weir equation:

Nonlevel weir equation:

$$Q = \frac{2Cb}{5(h_b - h_a)} (h_b^{2.5} - h_a^{2.5})$$

(C = 2.6, b = integral length of weir normal to flow in feet, h_a = head on the high end of the weir in feet, h_b = head on the low end of the weir in feet (5).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed using the conic method for computation of reservoir volume provided in HEC-1 (1). The summation of these increments below a given elevation is the storage below that level.

4. Floods are routed through the spillway using HEC-1, modified Puls, to determine the capability of the spillway.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, August 1972.

(3) Soil and Water Conservation District of Ray County, Watershed Work Plan, Willow Creek Watershed, Ray County, Missouri, November 1965.

(4) U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, Hydraulics of Broad-Crested Spillways, Technical Release No. 39, Design Unit, May 1968.

(5) Techniques of Water-Resources Investigations of the United States Geological Survey, Measurement of Peak Discharge at Dams by Indirect Methods, by Harry Hulsing, United States Department of the Interior, Geological Survey, United States Government Printing Office, Washington, D.C., 1967.

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
     1          A1MISSOURI DAM INSPECTION PROGRAM
     2          A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
     3          A3RAY COUNTY NO A-27
     4          B    240       0       6       0       0       0       0       0       0       0
     5          B1     5
     6          J      1       9       1
     7          J1   .10     .20     .25     .30     .35     .40     .45      .5      1.
     8          K      0       1                               3       1
     9          K1   24 HR PMF INFLOW A-27
    10          M      1       2     .36                       1
    11          P              24.5     101     120     130
    12          T                                                       -1      -84
    13          W2           .29
    14          X                       1
    15          K      1       2                                       1
    16          K1   ROUTE THROUGH RESERVOIR A-27
    17          Y                                       1       1
    18          Y1     1                                                -1      -1
    19          Y4755.85756.    756.5   757.    758.    758.8   759.3   760.6   761.4   762.1
    20          Y4762.8 763.5
    21          Y50.    1.5     13.7    28.9    30.     30.7    73.     155.    350.    1232.
    22          Y53135. 5706.
    23          $S168.  258.    630.
    24          $E755.85760.    770.
    25          $$755.85
    26          $D760.93
    27          K      99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .20	RATIO 3 .25	RATIO 4 .30	RATIO 5 .35	RATIO 6 .40	RATIO 7 .45	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	1	.36	1	320.	641.	801.	961.	1121.	1282.	1442.	1602.	3204.
	(	.93)	(	9.07)(	18.15)(	22.68)(	27.22)(	31.75)(	36.29)(	40.83)(	45.36)(	90.73)
ROUTED TO	2	.36	1	30.	93.	131.	176.	249.	322.	505.	735.	2742.
	(	.93)	(	.84)(	2.64)(	3.72)(	5.00)(	7.06)(	9.12)(	14.29)(	20.81)(	77.64)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 , ...

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	755.85	755.85	760.93
STORAGE	168.	168.	293.
OUTFLOW	0.	0.	235.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	757.80	0.00	210.	30.	0.00	18.40	0.00
.20	759.62	0.00	250.	93.	0.00	16.20	0.00
.25	760.23	0.00	266.	131.	0.00	18.20	0.00
.30	760.69	0.00	284.	176.	0.00	18.10	0.00
.35	760.99	.06	295.	249.	1.70	17.40	0.00
.40	761.29	.36	306.	322.	2.80	17.10	0.00
.45	761.52	.59	315.	505.	3.20	16.40	0.00
.50	761.71	.78	321.	735.	3.40	16.30	0.00
1.00	762.66	1.73	357.	2742.	5.70	16.00	0.00

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
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    2  A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
    3  A3RAY COUNTY NO A-27
    4  B   238    0    5    0    0    0    0    0    0    0
    5  B1    3
    6  K     0    1                        3    1
    7  K1   24 HR 100 YR INFLOW A-27
    8  M     0    2   .36                  1
    9  O   238
   10  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   11  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   12  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   13  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   14  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   15  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   16  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   17  O1  .006 .006 .015 .015 .015 .015 .015 .015 .015 .015
   18  O1  .015 .015 .015 .015 .015 .015 .015 .015 .015 .015
   19  O1  .015 .015 .015 .015 .015 .015 .015 .015 .015 .015
   20  O1  .015 .015 .015 .015 .015 .015 .015 .015 .028 .028
   21  O1  .028 .028 .028 .028 .028 .028 .028 .028 .028 .028
   22  O1  .028 .028 .028 .028 .028 .028 .029 .029 .029 .029
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   26  O1  .029 .029 .028 .028 .028 .028 .028 .028 .028 .028
   27  O1  .028 .028 .028 .028 .028 .028 .028 .028 .028 .028
   28  O1  .015 .015 .015 .015 .015 .015 .015 .015 .015 .015
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   35  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   36  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   37  O1  .006 .006 .006 .006 .006 .006 .006 .006 .006 .006
   38  O1  .006 .006 .006 .006 .006 .006 .006 .006
   39  T                                   -1   -69
   40  M2          .46
   41  X                 1
   42  K     1    2                        1
   43  K1   ROUTE THROUGH RESERVOIR A-27
   44  Y                       1    1
   45  Y1    1                                -1   -1
   46  Y4755.35756.  756.5  757.  758.  758.8  759.3  760.6  761.4  762.1
   47  Y4762.8 763.5
   48  Y50.   1.5    13.7   28.9   30.   30.7   73.   155.   350.  1232.
   49  Y53135. 5706.
   50  $S168.  258.  630.
```

```
51              $E755.85760.    770.
52              $S755.85
53              $D760.93
54              K      99
```

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

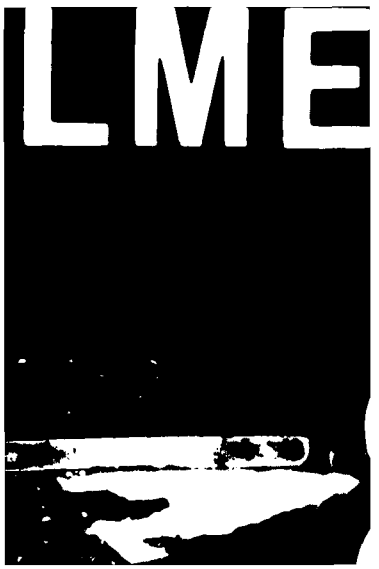
		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	590.	133.	39.	39.	.36
		(16.70)(	3.78)(	1.11)(	1.11)(	.93)
ROUTED TO	2	30.	30.	15.	15.	.36
		(.86)(	.86)(	.42)(	.42)(	.93)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	755.85	755.85	760.93
STORAGE	168.	168.	293.
OUTFLOW	0.	0.	235.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	758.41	0.00	224.	30.	0.00	18.33	0.00


LME